



Othman, M., Cooper, J., Pirrera, A., & Weaver, P. (2016). Multilevel Aeroelastic Tailoring For Composite Aircraft Wings. In *ICCS19 19th International Conference on Composite Structures* (pp. 50). (Structural and Computational Mechanics). <https://doi.org/10.15651/978-88-748-8977-8>

Peer reviewed version

Link to published version (if available):
[10.15651/978-88-748-8977-8](https://doi.org/10.15651/978-88-748-8977-8)

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This is the accepted author manuscript (AAM). The final published version (version of record) is available online via Società Editrice Esculapio at <http://dx.doi.org/10.15651/978-88-748-8977-8>. Please refer to any applicable terms of use of the publisher.

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Multilevel Aeroelastic Tailoring For Composite Aircraft Wings

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Abstract

Generally, the development of aircraft structures consists of a conceptual, preliminary and detailed design phase. All of these require a multidisciplinary approach involving aerodynamics, structural and flight mechanics. One of the main challenges at the preliminary design stage is to tailor structural dimensions and material properties to minimise weight whilst simultaneously satisfying constraints such as allowable stresses, strains and buckling and meeting aerodynamic, manufacturing, certification and fuel requirements.

The objective of this study is to develop a multilevel optimisation strategy for the aeroelastic tailoring of aircraft composite wings, including geometric and material uncertainties. In the proposed approach, the first level aims at minimising the weight of a baseline wing design for given static loads, subject to stress, buckling and aeroelastic (i.e. flutter and divergence) constraints. In second level, the design space is expanded to include parametric uncertainties and the structure is further optimised this time including gusts, flutter and divergence analyses. Polynomial Chaos Expansion is used here as the non-sampling-based method for uncertainty quantification and sensitivity analyses.

A regional aircraft wing model is used as the baseline for comparison. The optimisation procedures are performed using MSc Nastran. The advantages of using a multilevel optimisation approach include: (i) the possibility to reduce the numbers of design variables at the various optimisation levels and (ii) the capability of performing optimisation on different discipline of studies simultaneously.

Results show that the proposed method can provide an optimised wing structure whose robustness to uncertainties is both definite and measurable.

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